

Figure 28 is a side view of a tissue pad of the clamp coagulator;

Figure 29 is a front view of a tissue pad of the clamp coagulator;

5        Figure 30 is a perspective view of a tissue pad of the clamp coagulator;

Figure 31 is a bottom perspective view of a clamp arm of the camp coagulator;

10        Figure 32 is a first cross-sectional view of the clamp arm illustrated in Figure 31; and

Figure 33 is a second cross-sectional view of the clamp arm illustrated in Figure 31.

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Detailed Description of the Invention

The present invention will be described in combination with ultrasonic instruments as described herein. Such description is exemplary only, and is not intended to limit the scope and applications of the invention. For example, the invention is useful in combination with a multitude of ultrasonic instruments including those described in, for example, U.S. Patents Nos. 5,938,633; 5,935,144; 5,944,737; 5,322,055, 5,630,420; and 5,449,370.

25        Figure 1 illustrates a plan view of an ultrasonic system 10 comprising an ultrasonic signal generator 15 with a sectioned plan view of a sandwich type ultrasonic transducer 82, hand piece housing 20, and clamp coagulator 120 in accordance with the present invention. Clamp coagulator 120 may be used for open or laparoscopic surgery. The ultrasonic transducer 82, which is known as a

30        "Langevin stack", generally includes a transduction portion 90, a first resonator or end-bell 92, and a second resonator or fore-bell 94, and ancillary components. The ultrasonic transducer 82 is preferably an integral number of one-half system

wavelengths ( $n\lambda/2$ ) in length as will be described in more detail later. An acoustic assembly 80 includes the ultrasonic transducer 82, mount 36, velocity transformer 64 and surface 95.

5           The distal end of end-bell 92 is connected to the proximal end of transduction portion 90, and the proximal end of fore-bell 94 is connected to the distal end of transduction portion 90. Fore-bell 94 and end-bell 92 have a length determined by a number of variables, including the thickness of the transduction portion 90, the density and modulus of elasticity of the material used to  
10       manufacture end-bell 92 and fore-bell 94, and the resonant frequency of the ultrasonic transducer 82. The fore-bell 94 may be tapered inwardly from its proximal end to its distal end to amplify the ultrasonic vibration amplitude as velocity transformer 64, or alternately may have no amplification.

15           The piezoelectric elements 100 may be fabricated from any suitable material, such as, for example, lead zirconate-titanate, lead meta-niobate, lead titanate, or other piezoelectric crystal material. Each of the positive electrodes 96, negative electrodes 98, and piezoelectric elements 100 has a bore extending through the center. The positive and negative electrodes 96 and 98 are electrically  
20       coupled to wires 102 and 104, respectively. Wires 102 and 104 are encased within cable 25 and electrically connectable to ultrasonic signal generator 15 of ultrasonic system 10.

          Ultrasonic transducer 82 of the acoustic assembly 80 converts the electrical  
25       signal from ultrasonic signal generator 15 into mechanical energy that results in primarily longitudinal vibratory motion of the ultrasonic transducer 82 and an end-effector 180 at ultrasonic frequencies. When the acoustic assembly 80 is energized, a vibratory motion standing wave is generated through the acoustic assembly 80. The amplitude of the vibratory motion at any point along the  
30       acoustic assembly 80 depends on the location along the acoustic assembly 80 at which the vibratory motion is measured. A minimum or zero crossing in the vibratory motion standing wave is generally referred to as a node (i.e., where

motion is usually minimal), and an absolute value maximum or peak in the standing wave is generally referred to as an anti-node. The distance between an anti-node and its nearest node is one-quarter wavelength ( $\lambda / 4$ ).

5        Wires 102 and 104 transmit the electrical signal from the ultrasonic signal generator 15 to positive electrodes 96 and negative electrodes 98. A suitable generator is available as model number GEN01, from Ethicon Endo-Surgery, Inc., Cincinnati, Ohio. The piezoelectric elements 100 are energized by an electrical signal supplied from the ultrasonic signal generator 15 in response to a foot switch  
10    118 to produce an acoustic standing wave in the acoustic assembly 80. The electrical signal causes disturbances in the piezoelectric elements 100 in the form of repeated small displacements resulting in large compression forces within the material. The repeated small displacements cause the piezoelectric elements 100 to expand and contract in a continuous manner along the axis of the voltage gradient,  
15    producing longitudinal waves of ultrasonic energy. The ultrasonic energy is transmitted through the acoustic assembly 80 to the end-effector 180.

      In order for the acoustic assembly 80 to deliver energy to end-effector 180, all components of acoustic assembly 80 must be acoustically coupled to the  
20    ultrasonically active portions of clamp coagulator 120. The distal end of the ultrasonic transducer 82 may be acoustically coupled at surface 95 to the proximal end of an ultrasonic waveguide 179 by a threaded connection such as stud 50.

      The components of the acoustic assembly 80 are preferably acoustically  
25    tuned such that the length of any assembly is an integral number of one-half wavelengths ( $n\lambda / 2$ ), where the wavelength  $\lambda$  is the wavelength of a pre-selected or operating longitudinal vibration drive frequency  $f_d$  of the acoustic assembly 80, and where  $n$  is any positive integer. It is also contemplated that the acoustic assembly 80 may incorporate any suitable arrangement of acoustic elements.

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      Referring now to Figures 2A and 2B, an exploded perspective view of the clamp coagulator 120 of the surgical system 10 in accordance with the present